

PRESSURE DROP PERFORMANCE IN GAS CUSTODY TRANSFER THROUGH DOMESTIC GAS METER OPERATIONS

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ABSTRACT

Ranked 12th in the world for its natural gas reserves, standing with 82.5 trillion metric standard cubic feet, Malaysia, has certainly emerged as a major exporter and gas user globally. It was only lately in December 1984 that Petronas Gas Bhd. (PGB) started a pilot project to supply piped in natural gas in Terengganu which eventually marked the beginning of the Peninsular Gas Utilisation (PGU) project. The noble aim of the project was to bring natural gas from our offshore fields to the consumers. In line with this, Malaysia has attained and thus practicing the knowledge of gas transmission and distribution. At present, the increasing number of gas domestic customer either employing Natural Gas (NG) or Liquefied Petroleum Gas (LPG) as their burning fuel has driven attention towards accuracy of gas transfer. Losses to custodian may have significant impact in terms of monetary returns. This type of losses may be directly related to the effect of measurement accuracy and pressure losses. Therefore there is a need to study pressure performance in low flowrate gas system in the domestic sector. In this particular research work, indigenous technology to construct a domestic gas meter calibrator has found its lead by establishing a prototype calibrator. A development of a scale model flow system using domestic gas meters, the pressure losses performance can be monitored carefully and could lead to the formulation and understanding of the pressure capacity and its consequence effect to the metering accuracy. Bench tests of this prototype has proven a great success and reliable. This is also in line with SIRIM initiative to establish standards in the domestic gas meter applications.

Key Words: Gas Custody Transfer, Pressure Drop and Domestic Gas Meter.

1.0 INTRODUCTION

The accurate metering of gas has become extremely important to companies involved in its transmission and distribution over the last decade. The main reasons for this are the increasing cost of energy, the mutual desire for fair dealing between the buyer and the seller and the increasing involvement of the governmental institutions. Furthermore, metering is now directly involved in determining the financial resources of gas companies. It is the 'cash register' of the incoming moneys, and must by its definition be accurate and dependable [1]. Therefore, technical factors such as pressure drop that effect the flow patterns of fluids through this meters is of great importance and should be investigated and analyzed [2].

This project has been carried out through the development of gas custody transfer modelling using domestic gas meter and reference meter to establish the operational accuracy of meters. This in hand will establish the operating conditions of the meter

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operations. Subsequently, the rig is used to obtain several test data by means of studying the pressure performance and losses in the model developed. The impact of the study will lead towards the understanding of the whole operations of the gas transfer in the domestic sector between supplier and gas users. The effect of pressure drop to measurement accuracy and losses to custodian is mainly studied. It had also established significant pattern and trending towards style of demand in the domestic sector based on pressure system studied.

The objective of this research is to study and understand the effect of pressure drop performance in gas custody transfer through gas meters operation in the domestic sector using several gases such as nitrogen, compressed air and LPG.

2.0 METER SELECTION

The selection of a gas metering system involves certain consideration given to various known factors. These factors may be gathered under four main criteria's namely technical, practical, legal and financial. The most important factor in this research is the pressure drop in gas custody transfer which falls under the technical criteria.

In the custody transfer measurement, gas measuring devices can be divided into two main categories that are quality or positive displacement type (Direct) and rate-of-flow or inferential type (Audit) [3]. The 'Direct' volumetric measuring meters has proved its superior over all other type of 'Audit' meters. This fact is borne out by experience over many years of exemplary operation [4]. Their incorporation into compact reduction/metering systems, without loss of accuracy or life, has been achieved by continuous and careful engineering development.

Diaphragm meters, a kind of positive displacement meter, are by far the most widespread, popular and commonly used type of meter being universally used for the domestic and other light commercial application [4].

They consist of a pressurised outer case with both inlet and outlet connections normally positioned on the upper surface. Inside this casing secured the measuring unit itself, which is made up from two identical shells, when brought and secured together, trap and hold a flexible diaphragm. The central area of each diaphragm trapped between two thin yet rigid plates which in turn are connected via a series of rods and levers to pair of slide valves. A mechanical counter generally located on the front of the case displays the movement of the diaphragms in volumetric units (m^3 or ft^3).

The slide valves guide/transfer the following gas alternatively from one side of the diaphragm to the other. The flowing gas once measured is transferred directly to the outlet connection of the meter. The linkage controlled by the oscillation of the diaphragm, transmit a rotary motion to the indicating device (index). With each operating cycle of the meter, an accurate volume of gas is registered by the meter index. This known volume is known as the cycle volume of the meter. This operating principle is therefore truly 'positive displacement' [5][6].

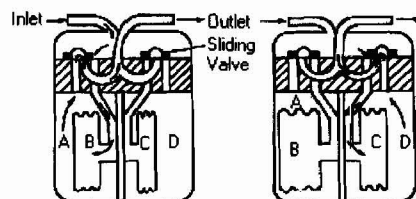


Figure 1 Diaphragm gas meter at two stages

3.0 PRESSURE DROP

As gas flows through the passages and the chambers of a typical positive gas displacement meter, its pressure decreases slightly due to mechanical and fluid friction.

The magnitude of the pressure loss depends on the shape of the diaphragm and the packing glands. At low flowrates the mechanical friction of the bearings and sliding parts predominates. At high flowrates, the flow losses predominate since mechanical friction increase only slightly with increasing flowrate. Figure 2 shows a graphical presentation of the effect of flowrate on pressure drop for various gases. From the figure, it can be seen that pressure drop increases with increasing flowrate [5][7].

The European made turbine and rotary meters are usually standardized using G-rating for maximum capacity of each connection size meter. The relation between G-rating and maximum capacity (Q_{max}) is $Q_{max} = 1.6 \times G\text{-rating}$. According to the European regulations, the maximum pressure drop must be lower than the following values when measuring air at 1.2 kg/m^3 (under low pressure) [3]:

- i. From G 1.6 to G 10: 2 mbar
- ii. From G 16 to G 40: 3 mbar
- iii. From G 65 to G 650: 4 mbar

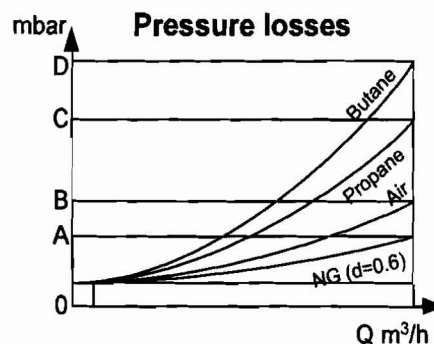


Figure 2 Pressure losses for gases at different flowrates

In a medium or high pressure system, the maximum allowable pressure differential across the meter depends on the pressure and density of the gas and the manufacturer's limiting criteria [6][8].

4.0 EXPERIMENTAL SET UP AND PROCEDURES

The experiments to determine pressure drop performance were carried out on a bench scale gas custody transfer model using domestic gas meter and reference meter to establish the operational accuracy of the meters. The developed model was purposely dedicated for the use of domestic gas meters and has a capability to carry out series of test for five meters in one single operation. The operating flow rate adopted is based on the minimum to maximum flow rate normally used within domestic and commercial sector in Malaysia.

The type of reference meter used is "American Meter Company" wet type gas meter with a maximum flow rate of 40 l/min and accuracy in the range of $\pm 0.25\%$ to 0.5% . In order to enable a proper recording system, six sets of Endress & Hauser pressure transducers with the operating range of 0 to 0.1 bar were employed to transmit the

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recorded pressure to Endress & Hauser visual data manager. Gas is supplied to the calibration bench using manifold system with an outlet pressure of 14 psig having a dimension of ½ inch Teflon hose and tubing.

Compressed air, LPG and nitrogen could be used as source medium. These gases are in a constant pressure and stabilized by passing through a pressure regulator. After selecting the test item, inspection and pressure drop test procedure is started following by the opening and closing sequence of the control valves. The system is further stabilized after some running mode and the measurement of temperature and pressure is taken. After certain accumulated amount of standard flow rate, the test results could then be obtained using temperature and pressure values conversion. The inlet flow line to each meter is equipped with a set of pressure transducer to measure the inlet pressure. The pressure drop through a particular meter is then obtained by determining the differential pressure value between the pressure transducer for that particular meter and the pressure transducer for the next meter. The pressure drop for the other meters is obtained in the same manner. The conceptual drawing of the testing model is shown in Figure 3.

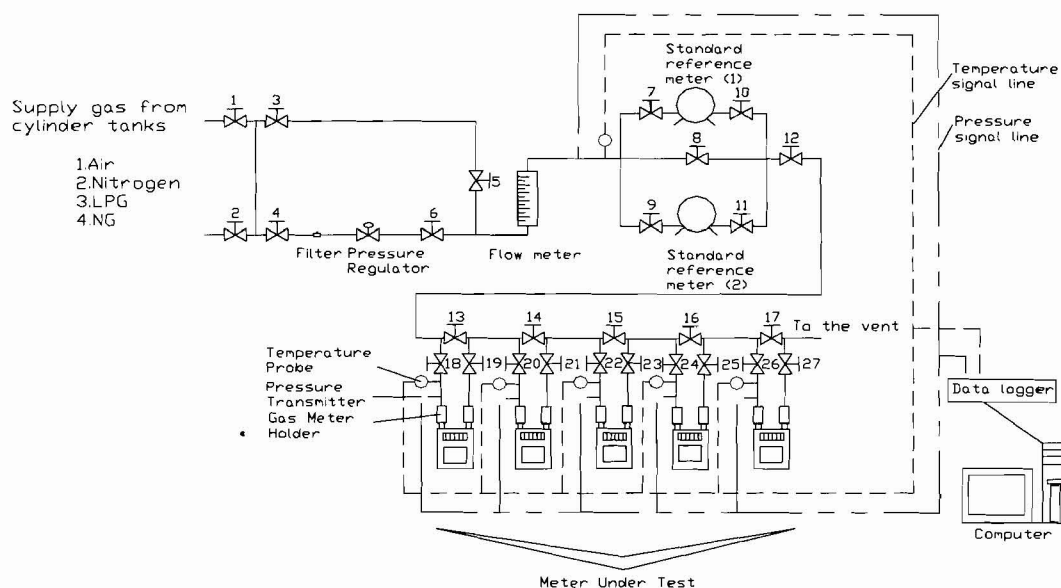


Figure 3 Conceptual drawing of gas custody transfer modeling using domestic gas meter and reference meter

5.0 RESULTS AND DISCUSSION

The pressure drop test is carried out to investigate the effect of pressure drop at different flow on used and new diaphragm gas meters. The experimental results of pressure drop tests are shown in Figure 4 to Figure 9. The figures mentioned shows data for experimental results for flowrates ranging from 0.1 to 1.1 m³/h. The pressure drop increased gradually from 0.4" w.c (water column) (0.0010 bar) to 2.00" w.c. (0.005 bar) for diaphragm gas meters.

Pressure drop is highly dependable on the friction coefficient, tubing or passage length, tubing diameter and mean velocity of the fluid. In this particular work,

parameters such as length, diameter and fluid medium for each experimental procedure were fixed. The only parameter that varies is the velocity of the fluid. In other words pressure drop increases with the velocity of the fluid medium. From Figure 4 to Figure 9 differences of pressure drop obtained are substantially contributed by the tubing losses and individual characteristics of the meters. The results for new meters shown in Figures 4 to 6 were manufactured by the same factory thus indicate small differences of pressure drop. Each of these meters has slight differences in pressure drop range due to manufacturing differences and minor tolerance in the mechanical parts. However, difference of pressure drop limit does not exceed 1.0 " w.c. (0.0025 bar) except for meter indicated as Old Meter 1. This meter probably experienced internal failures. The same problem does not arise for other meters because the pressure drop data obtained falls in the tolerable range.

Figure 7 to Figure 9 show pressure drop versus different flow rates for new and used meters. The comparison between new meter and old meter is carried out to determine the effect of continuous usage of meters. Older meters might have the tendency to show inaccurate readings due to the mechanical wear and tear over the period of its usage as compared to newer meters. However, the results show that used meter had almost similar range of pressure drop with the new gas meter. The results indicated show that the pressure drop for used meters and new meters is almost identical. Only Old Meter 1 shows a higher pressure drop. This phenomenon might be contributed by the mechanical failures in the meter. Therefore the operation duration of the meter does not give significant effect to the pressure drop of the meters.

As the velocity of the test fluid increases, the friction loss in the tubing also increases. This condition causes increase in pressure losses with the increase of velocity of the test fluid. Whenever test fluid passes through meters, some energy of the test fluid has to be used to generate the movement of mechanical part of the meter in order to obtain the reading measurement of the test fluid. The internal resistance of the meter subsequently creates pressure drop in the meter which is considered as unavoidable. In the common practices, pressure drop data of gas meters will be provided by the meter manufacturers. Generally, the total pressure drop obtained from this experiment is below 2.0 " w.c. (0.005 bar) and it is in with the manufacturers requirements and the European Standards which was mentioned previously.

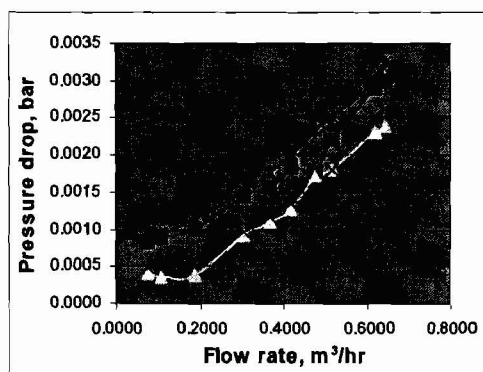


Figure 4 Plot of pressure drop against flow rate for 4 sets of new gas meters using LPG

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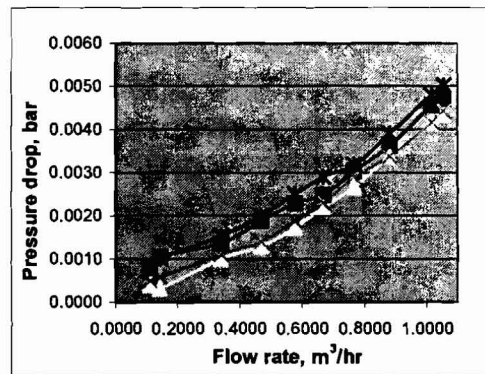


Figure 5 Plot of pressure drop against flow rate for 4 sets of new gas meters using nitrogen

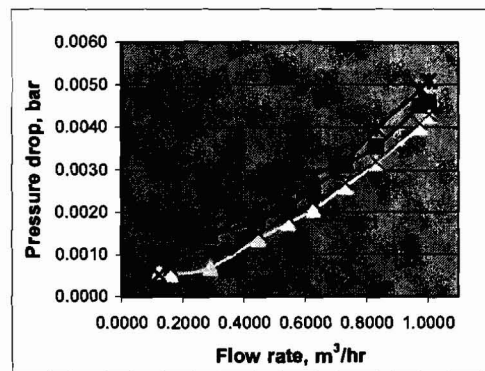


Figure 6 Plot of pressure drop against flow rate for 4 sets of new gas meters using compressed air

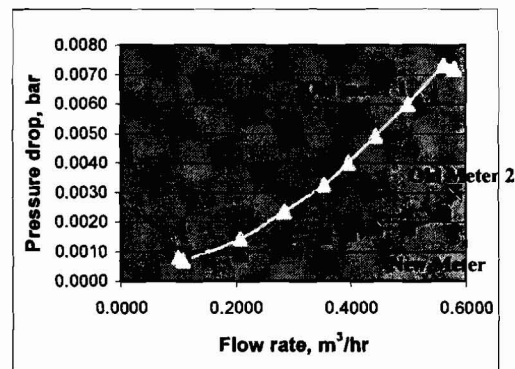


Figure 7 Plot of pressure drop against flow rate for used and new gas meters using LPG

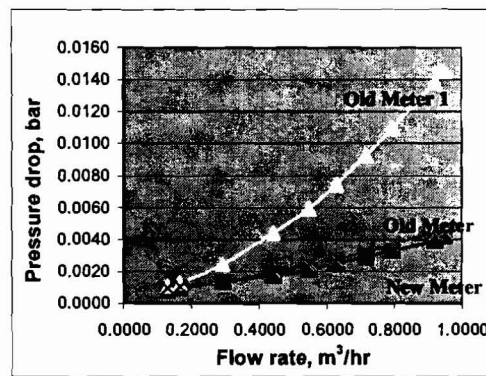


Figure 8 Plot of pressure drop against flow rate for used and new gas meters using nitrogen

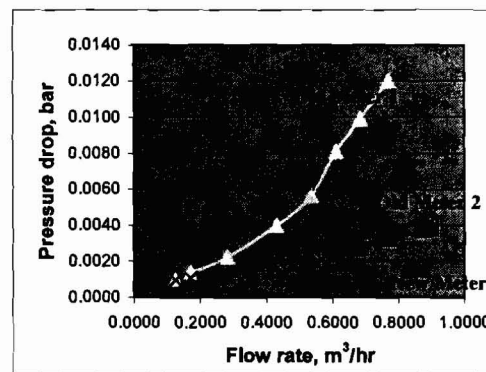


Figure 9 Plot of pressure drop against flow rate for used and new gas meters using compressed air

6.0 CONCLUSION

The experimental results obtained shows that the pressure drop for the diaphragm meter increases with the increasing flow rate of the test fluid. The pressure performance for new and used meters are almost identical except for cases where the meter has mechanical failure. Further research should be carried out to establish in-depth understanding in the fundamentals of gas custody transfer mainly in the effect of parameters like temperature and flow rate on the overall flow patterns of gas.

To further enhance the capabilities of the gas custody transfer model, it is suggested that the entire system should be automated through the development of a control system which includes automatic valves and an automatic data acquisition system to reduce the effects of pressure drop on the overall performance of the model.

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